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Forest Health Protection
Pacific Southwest Region

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To: District Ranger, Beckwourth Ranger District, Plumas National Forest

Subject: Evaluation of stand conditions and bark beetle activity in the Jackson Project (FHP Report NE10-06)

At the request of Geoffrey Kaeberle, Silviculturist, Beckwourth Ranger District, I visited the Jackson Project on March 19, 2010 and again on June 2, 2010. The objectives of these site visits were to evaluate current stand conditions, determine the potential for future bark beetle caused tree mortality and discuss proposed alternatives. Recommendations provided by this evaluation will assist with planning forest fuel and tree density reduction activities. Geoffrey Kaeberle, Janice Sangunitto, Assistant Silviculturist and Dani Swantic, District Culturist, accompanied me to the field on June 2.

Background

The Jackson Project is located just north of the community of Blairsden, CA (T 22 and 23 N, R 12 and 13 E). The elevation of the site ranges from 4400 to 7000 feet with annual precipitation ranging from 30 – 50 inches. Low elevation and south facing slopes at the southern end of the project area are a mix of ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*Pinus jeffreyi*), Douglas-fir (*Psuedotsuga menziesii*), Incense cedar (*Libocedrus decurrens*), sugar pine (*Pinus lambertiana*) and black oak (*Quercus kelloggii*) while north facing upper elevation slopes consist of white fir (*Abies concolor*), sugar pine, incense cedar, Douglas-fir, ponderosa and Jeffrey pine. The management objectives for this project are to create defensible fuel profile zones (DFPZ) with a variable thinning strategy. Variable thinning would reduce stand density and change species composition to a more sustainable condition by removing trees from all size classes (< 30" dbh), creating gaps and clumps, and removing competition from around old growth trees. This type of treatment would begin to move stands to a more resilient condition

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that is consistent with Regional ecosystem restoration goals.

Observations

High stand density combined with the recent dry weather, and dwarf mistletoe and annosus root disease in some areas, have contributed to an increase in bark and wood boring beetle caused tree mortality within the project area. Most of this mortality is occurring in white fir and Douglas-fir but scattered mortality of all conifer species was recorded during both site visits.

The most prominent tree mortality in the southern portion of the Jackson Project area is occurring in Douglas-fir as a result of attacks by the flatheaded fir borer (*Melanophila drummondi*). Many larger diameter (> 16" dbh) Douglas-fir are dead or dying from fir borer attacks. Branch flagging and top killing of Douglas-fir crowns caused by the Douglas-fir engraver beetle (*Scolytus unispinosus*) was also observed in this same area.

Fir engraver beetle (*Scolytus ventralis*) is attacking and killing white fir resulting in the highest level of mortality found within the project area. The most notable white fir mortality was observed in a previously fire-injured stand near Penman Saddle.

Western pine beetle (*Dendroctonus brevicomis*) and Jeffrey pine beetle (*Dendroctonus jeffreyi*) caused mortality of ponderosa and Jeffrey pine trees is limited relative to other bark beetle activity and is scattered throughout the project area.

High infection levels of western dwarf mistletoe (*Arceuthobium campylopodum*) were observed in Jeffrey pine stands on shallow soils near Penman Saddle. A few trees are being attacked by Jeffrey pine beetle and possibly wood boring beetles such as the California flatheaded borer (*Melanophila californica*).

An area of Jeffrey pine just northwest of Penman Peak was found to be infested with an unknown foliar insect that was causing partial browning of the needles similar to injury caused by black pineleaf scale (*Nuculaspis californica*).

White pine blister rust (*Cronartium ribicola*) is causing branch dieback in sugar pine along the 23N06 road.

Incense cedar is dying where it occurs on shallow soils on lower south facing slopes. Incense cedar rust (*Gymnosporangium libocedri*) was observed on many dead and dying trees in this area but only high infection levels appeared to be contributing to tree mortality. Most incense cedar mortality appears to be strictly drought and density related.

Discussion and Recommendations

Current tree mortality attributable to insects and/or pathogens is patchy within the project area, and mostly restricted to white fir and Douglas-fir at relatively low levels. However, Forest Health Protection aerial surveys of the project area have detected an increase in mortality during

the past year over the two previous years and many of the dead trees observed during this site visit have faded since the 2009 survey. Elevated levels of tree mortality in this area, as well as in the rest of the Sierra Nevada range, are strongly associated with periods of below normal precipitation and high stand density. Successive dry years can exacerbate unhealthy stand conditions, such as those that exist within the Jackson Project area; resulting in higher levels of bark beetle caused tree mortality.

The target stocking levels for the District proposed thinning treatments should reduce the density in most stands to a level that reduces the risk of bark beetle caused mortality. In most cases, thinning to a stand density that is 80% or less of "normal" basal area for the site would effectively reduce tree competition for limited water and nutrients and reduce the susceptibility to future bark beetle related mortality. Thinning to this level would also be consistent with recent direction from the Regional Forester that suggests designing thinnings to "ensure that density does not exceed an upper limit (for example: 90% of normal basal area, or 60% of maximum stand density index)" and to "design thinnings to ensure that this level will not be reached again for at least 20 years after thinning." (Regional Forester letter, "Conifer Forest Density Management for Multiple Objectives", July 14, 2004). .

When planning thinning treatments, it should be recognized that the target stand density is an average to be applied across the landscape and some variability may be desired. Individual high value trees, such as mature pines and black oaks, should benefit by having the stocking around them reduced to lower levels. Areas of pure or nearly pure ponderosa and Jeffrey pine would also benefit from lower stocking levels as well as an increase in species diversity. Allowing for denser tree spacing and pockets of higher canopy cover may be desirable around potential wildlife trees, such as forked and/or broken-topped trees. The variable thinning plan proposed by the District should achieve this type of stand diversity and be consistent with Regional ecosystem restoration goals.

When implementing thinning projects, retaining more drought tolerant species such as ponderosa pine, Jeffrey pine, sugar pine and Douglas-fir over incense cedar and true fir will increase species diversity and make stands more resilient to disturbance agents. Ponderosa and Jeffrey pine should be retained over Douglas-fir in stands on lower elevation, south facing slopes. In addition, when selecting trees for removal, preference should be given to trees heavily infected with dwarf mistletoe, root disease and trees infested with bark beetles. Small group selections should be utilized to remove root disease pockets and clumps of trees with heavy dwarf mistletoe infections. For all thinning operations, it is recommended that a registered borate compound be applied to all freshly cut conifer stumps >14" dbh in order to reduce the chance of new annosus root disease centers being created through harvest activity. However, the treatment of true fir stumps may not be beneficial if stands already have a high level of fir, or S-type, annosus.

Sugar pine should be retained as much as possible during any thinning operation in order to preserve genetic diversity, especially white pine blister rust (*Cronartium ribicola*) resistant individuals. White pine blister rust, a non-native pathogen, has continued to weaken and kill this species over most of its range since its introduction into the Pacific Northwest in 1910. Identification and protection of local rust resistant trees for seed collection, if not already occurring, will aid in the future planting of rust resistant seedlings. Planting selected openings

created through thinning operations with rust resistant stock would help insure this species persists in the area.

Infection of incense cedar by incense cedar rust would generally not result in tree mortality during periods of normal to above normal precipitation as this disease rarely causes any more injury than scattered dieback of small branches. However, when combined with moisture stress, these trees are at a higher risk than uninfected trees and a continuation of dry and overstocked conditions may result in further mortality. To reduce future mortality, select heavily infected trees (trees with excessive brooms) for removal during thinning operations.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431.

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Insect and Disease Information

Western pine beetle

The western pine beetle, *Dendroctonus brevicomis*, has been intensively studied and has proven to be an important factor in the ecology and management of ponderosa pine throughout the range of this host species (Miller and Keen 1960). This insect breeds in the main bole of living ponderosa pine larger than about 8 inches dbh. Normally it breeds in trees weakened by drought, overstocking, root disease, dwarf mistletoe or fire. Adult beetles emerge and attack trees continuously from spring through fall. Depending on the latitude and elevation, there can be from one to four generations per year.

Evidence of Attack

Initial attacks are made about mid-bole and subsequent attacks fill in above and below. Pitch tubes are formed on the tree trunk around the entry holes. The pitch tubes are red-brown masses of resin and boring dust. Relatively few, widely scattered, white pitch tubes usually indicate that the attacks were not successful and that the tree should survive. Pheromones released during a successful attack attract other western pine beetles. Attacking beetles may spill over into nearby apparently healthy trees and overwhelm them by sheer numbers.

Life Stages and Development

These beetles pass through the egg, larval, pupal and adult stages during a life-cycle that varies in length dependent primarily upon temperature. Adults bore a sinuous gallery pattern in the phloem and the female lays eggs in niches along the sides of the gallery. The larvae are small white grubs that first feed in the phloem and then mine into the middle bark where they complete most of their development. Bluestain fungi, introduced during successful attacks, contribute to the rapid tree mortality associated with bark beetle attacks.

Conditions Affecting Outbreaks

Outbreaks of western pine beetle have been observed, and surveys made, in pine regions of the West since 1899 (Hopkins 1899; cited in Miller and Keen 1960). An insect survey completed in 1917 in northern California indicated that over 25 million board feet of pine timber had been killed by bark beetles. Information from surveys initiated in the 1930s indicates that there were enormous losses attributed to western pine beetle around that time. During the 1930's outbreak, most of the mortality occurred in stands of mature or overmature trees of poor vigor (Miller and Keen 1960). Group kills do not typically continue to increase in size through successive beetle generations as is typical with Jeffrey pine beetle. Rather, observations indicate that emerging beetles tend to leave the group kill area to initiate new attacks elsewhere.

The availability of suitable host material is a key condition influencing western pine beetle outbreaks. In northeastern California, drought stress may be the key condition influencing outbreaks. When healthy trees undergo a sudden and severe moisture stress populations of western pine beetle are likely to increase. Healthy trees ordinarily produce abundant amounts of resin, which pitch out attacking beetles, but when deprived of moisture, stressed trees cannot produce sufficient resin flow to resist attack. Any condition that results in excessive demand for moisture, such as tree crowding, competing vegetation or protracted drought periods; or any condition that reduces that ability of the roots to supply water to the tree, such as mechanical damage, root disease, or soil compaction, can cause moisture stress and increase susceptibility to attack by the western pine beetle. Woodpeckers and predaceous beetles are natural control agents when beetle populations are low.

Fir Engraver

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood and the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year; however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Jeffrey Pine Beetle

The Jeffrey pine beetle is the principle bark beetle found attacking Jeffrey pine, which is its only host. It is a native insect occurring from southwestern Oregon southward through California and western Nevada to northern Mexico. The beetle normally breeds in slow-growing, stressed trees. The beetles prefer trees which are large, mature, and occur singly rather than in groups. Yet when an epidemic occurs, the beetle may attack and kill groups of trees greater than 8 inches in diameter, regardless of age or vigor. Often the beetle infests lightning-struck or wind-thrown trees, but does not breed in slash.

Evidence of Attack

Presence of the beetle is usually detected when the foliage changes color. The color change of the foliage is related to the destruction of the cambium layer by the beetle. Generally, the top of the crown begins to fade in a slow sequence, with the needles turning from greenish yellow, to sorrel, and finally to reddish brown. By the time the tree is reddish brown, the beetles have usually abandoned the tree. Another sign of beetle attack is large, reddish pitch tubes projecting from the bark of the infested tree. If examined carefully, pitch tubes can be detected on infested green trees prior to crown fade. Jeffrey pine beetles have a distinctive "J" shape egg gallery pattern on the inner bark. Larval mines extend across the grain and end in open, oval-shaped pupal cells.

Life Stages and Development

The Jeffrey pine beetle is one of the larger pine bark beetles in California. The beetle has a 4 life stages, egg, larva, pupa, and adult. The adults are stout, cylindrical, black, and approximately five-sixteenths of an inch long when mature. The egg is oval and pearly-white. The larva is white, legless, and has a yellow head. The pupa is also white but is slightly smaller than the mature larva. The life cycle is normally completed in one year in the northern part of the range, but in the southern part, two generations per year may occur. The principle period of attack is in June and July, but attacks also are frequent in late September and early October. Similar to other Dendroctonus species, Jeffrey pine beetles use pheromones that attract other beetles to a tree, causing a mass attack that tends to overcome the tree's natural resistance. Blue stain fungi are associated with Jeffrey pine beetle attacks and aid in overcoming the tree’s defenses.

Conditions Affecting Outbreaks

Normally the Jeffrey pine beetle is kept in check by its natural enemies, climatic factors and the resistance of its host. Similar to other Dendroctonus species, the availability of suitable host material is a key factor influencing outbreaks. Healthy trees ordinarily produce abundant amounts of resin, which pitches out attacking beetles. When deprived of moisture, or stressed by other factors such as disease or fire injury, trees cannot produce sufficient resin flow and become susceptible to successful beetle attacks.

Flatheaded Fir Borer

Flatheaded fir borers commonly breed in felled trees or those weakened by fire, defoliation, drought, or other types of disturbance. Trees infested are usually pole size or larger. Beetles can infest the entire tree or attacks can be confined to the upper crown and result in top kill. Flatheaded fir borers are considered less aggressive in their attacks on living trees than bark beetles. This beetle can be particularly aggressive on Douglas-fir growing on the edge of stands or scattered patches of trees on dry sites.

Detection of flatheaded fir borer attacks prior to the yellowing of the tree's crown is difficult. Unlike bark beetles, there are typically no external indicators of attack such as boring dust or pitch streams on the bark. For this reason, infestations are rarely diagnosed before the damage has already occurred. However, it is sometimes possible to identify infested green trees during the fall and winter months from the patches of bark removed by woodpeckers searching for beetle larvae. By the time the infested tree's foliage turns red, usually in the late spring or early summer in the year after attack, beetles have already left the tree. The only way to confirm a beetle attack is to remove a piece of bark and look for its distinctive gallery pattern. Larvae construct wide, winding galleries that increase in width as larvae grow. Galleries are filled with a brown dust packed in concentric lines. The removal of bark from the tree's lower bole does not guarantee detection of a flatheaded borer attack, since sometimes attacks are confined to the upper crown.

Although called a borer, the larvae of this large beetle feed and develop in the phloem/cambium interface, much like bark beetle larvae, and never bore into the tree's sapwood. The life cycle of the flatheaded fir borer normally requires one year. Adults emerge in the spring and feed on conifer needles before flying to a suitable host tree. Adult beetles can sometimes be seen resting on tree bark exposed to direct sunlight. Eggs are laid in bark crevices and upon hatching; larvae immediately bore into the inner bark. Larvae feed in the inner bark without boring into the sapwood. Late in the summer or early fall, larvae construct pupal cells in the outer bark. Winter is spent in the outer bark and adult beetles emerge the following spring.

Dwarf Mistletoe

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts. Dwarf mistletoe commonly predisposes true firs to Cytospora abietis canker, which can girdle and kill branches and occasionally kill trees.

Dwarf mistletoes spread by means of seed. During Fall, the ripening single-seeded fruit swells as the internal liquid pressure increases to the point of bursting the tiny fruit. The expoding fruit forcibly propels the seed as far as 60 feet. The seed is covered with a sticky substance and adheres to whatever it contacts. For infection to occur, the seed must stick to a needle or twig and then be moved by winter rain or snow to the base of a needle. The following Spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed after another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that, in still air, the seeds can travel a horizontal distance equal to the height in the tree from which it is launched. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread of most dwarf mistletoes within tree crowns usually averages less than one foot per year because of foliage density. Thus a lightly infected conifer on a good site can grow in height faster than dwarf mistletoe can spread up its crown. Such trees can survive dwarf mistletoe as long as they are not further infected from overstory trees or girdled by bole infections. An exception to this is gray pine or other conifers with sparse foliage. In gray pine, the vertical rate of dwarf mistletoe spread has been measured to be greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because signs of infection are generally exposed to view within a tree's crown. Signs include yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached, and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings. Since dwarf mistletoes require 2-4 years to form aerial shoots after infection, new infections are not apparent until the shoots appear.

White pine blister rust

White pine blister rust is caused by Cronartium ribicola an obligate parasite that attacks 5-needled pines and several species of Ribes spp. The fungus needs the two alternate hosts to survive, spending part of its life on 5-needled pines and the other on Ribes spp. The disease occurs throughout the range of sugar pine to the southern Sierra Nevada, but has not been reported further south. Infection of pines results in cankers on branches and main stems, branch mortality, top kill, and tree mortality.

Spores (aeciospores) produced by the fungus in the spring on pine bole or branch cankers are wind-disseminated to Ribes spp. where they infect the leaves. Spores (urediospores) produced in orange pustules on the underside of the leaves reinfect other Ribes spp. throughout the summer, resulting in an intensification of the rust. A telial spore stage forms on Ribes spp. leaves in the fall. Teliospores germinate in place to produce spores (sporida) which are wind-disseminated to pines and infect current year needles. Following infection, the fungus grows from the needle into the branch and forms a canker. After 2 or 3 years, spores are produced on the cankers and are spread to Ribes spp. to continue the cycle. Although blister rust may spread hundreds of miles from pines to Ribes spp., its spread from Ribes spp. back to pines is usually limited to a few hundred feet.

Branch cankers continue to enlarge as the fungus invades additional tissues and moves toward the bole. Branch cankers within 24 inches of the bole will eventually form bole cankers. Bole cankers result in girdling and death of the tree above the canker. Cankers that have margins more than 24 inches from the main bole are unlikely to reach the bole and only branch flagging will result.